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# Effect of production system, alternative treatments and calf rearing system on udder health in organic dairy cows☆

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ABSTRACT

In the last decade the main goals of organic dairying have been to attain acceptable levels of milk production, increase opportunities for animals to perform species own behaviour, resulting in improved animal welfare and animal health, and minimize the use of therapeutic interventions, including the reduction of the (preventive) use of antibiotics. Maintaining animal health without the use of therapeutic interventions is a major challenge for organic dairy farmers. In particular, udder health remains a major problem in both conventional and organic farming. In the QualityLowInputFood (QLIF) project udder health status and management were assessed in different production systems and European regions. These studies suggest that good udder health can be maintained in organic or low-input farming management systems. Novel strategies to control mastitis were evaluated and the potential of using internal teat sealers for the control of environment-associated pathogens was shown. Also oral application of a herd profile based single homeopathic remedy combined with homeopathic silica had a significant effect on cows with a relative low somatic cell count before drying-off. Suckling systems in calf rearing, as an integrated management approach, did not result in better udder health. None of the studies presented identified new variables affecting udder health. QLIF studies also demonstrated the importance of comparing udder health parameters in contrasting organic, low input and conventional production systems, since clear differences in antibiotic use against mastitis could be identified not only between organic and conventional systems, but also among dairy systems used in different EU-countries. Although alternative treatments used in organic systems could not be shown to be fully effective, results suggest that the use of individual or combined alternative strategies to improve udder health on organic or low-input farms warrants further investigation. Based on the results obtained it is recommended that future research should focus on identifying the reasons for variability in udder health between organic farms that use different management protocols to identify 'best current practice' when carrying out this research.


## 1. Introduction

Organic dairy production systems have been reported to provide various animal health and welfare, product quality and other societal benefits, associated with the four main principles of the International Federation of Organic Agriculture Movements (IFOAM): health, ecology, fairness and care ([1]; Butler et al., this issue). In the last decade, one of the main goals of organic dairying has been to attain acceptable levels of milk production, while at the same time improving product quality and safety, environmental impact and animal health and welfare. One way to attain the latter, is to reduce mastitis incidence, which is estimated to currently account for more than two-thirds of antibiotic use in organic dairy farming. However, maintaining udder health without the use of therapeutic antibiotics is still perceived as a major bottleneck for organic dairy farmers [2,3]. Also, clinical mastitis and high somatic cell counts (SCC) associated with poor udder health management cause substantial economic losses and hamper ani-

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mal welfare for both organic and conventional farmers. Factors affecting udder health include: milking frequency, equipment and method, dairy diets (e.g., nutrient imbalances, mineral and vitamin deficiencies resulting in metabolic disorders), breed and breeding strategies, outdoor management practices, housing systems and antibiotic and/or alternative intervention systems [4–6].

While significant R&D efforts have focused on improving udder health in conventional systems, also in recent years [7], the outcome of these studies has been of limited relevance for organic farms. Only few studies were carried out on organic farms [8–10]. Prophylactic dry-cow treatment with antibiotics can attain low SCC and lower mastitis pathogen levels in milk after calving, and is widely used in conventional farming in some European regions. However, to minimize risks of antibiotic residues in milk and transferable antibiotic resistance development in bacterial pathogens, this use of prophylactic antibiotics is prohibited under organic farming standards [11]. Organic regulations also encourage dairy farmers to use management and alternative treatments based preventive strategies rather than therapeutic antibiotic use for mastitis control. The strategies currently available and used by farmers to prevent udder infections are (1) improvement of farm management practices related to udder health, and (2) prophylactic alternative treatments of cows during the time of highest new infection risk, i.e., the dry period. However, there is also some concern about certain alternative treatments. For example, in the early 1990s the use of teat sealants was thought to be an appropriate treatment for organic farmers. However, more recently teat sealants have been criticized because they are based on saline solutions containing heavy metals, which may have negative environmental impact [12]. Also, they cannot be used for the treatment of sub-clinical mastitis.

Research into both alternative management and treatment approaches is very limited and has focused on dry cow management [13], purging of antibiotics [14,15] and use of alternative treatments [16–19]. Overall, there is still insufficient evidence to show that alternative treatments are effective enough to replace antibiotic therapy. There is also limited research at farm level comparing the effect of implementing complementary treatment methods such as homeopathy or etheric oils with conventional antibiotic therapy [20,21].

This paper presents the results of a range of studies focused on udder health carried out in organic, low-input and organic dairy production systems across Europe as part of the QualityLowInputFood (QLIF) project. This included studies focused on:

- Assessment of udder health status and factors affecting udder health status in different production systems and European regions.
- Testing alternative measures and management strategies to control or prevent udder health problems.
- Examination of the effects of improved farm management and farmers' skills on udder health through extension.

This paper brings together these different studies and discusses their implications, with respect to recommendations on how to approach udder health in organic dairy farming.

## 2. Methods

The QLIF project included four studies on udder health.

*Study 1*: A survey of antibiotic use against mastitis in organic, low-input and high-input conventional milking herds in Denmark, Italy, Sweden and the UK. This study focused primarily on the impact of management practices on milk quality, but also collected information on udder health and veterinary treatments.

*Study 2*: An on-farm study evaluating the effect of farm and animal-specific measures on udder health on Swiss organic dairy farms.

*Study 3*: An on-farm study of the effect of calf rearing system on heifer performance and udder health in the Netherlands.

*Study 4*: An on-farm evaluation of farm-measures and a one-year extension programme focused on implementing management changes to improve udder health under different climatic production conditions in Italy, the Netherlands and Switzerland.

This section briefly describes the methods used in each study.[1]

### 2.1. Study 1. Antibiotic use in low-input and high-input conventional milking herds

The main aim of this particular study was to investigate the impact of farm management systems on milk quality across four European Union (EU) countries: Italy, Sweden, Denmark, and the United Kingdom (UK). As part of this study, details of SCC and veterinary inputs were gathered and other management information was collected at herd level, thus allowing comparisons of udder health among these systems.

The description of the organic and low-input management systems, along with details of the sampling regimes, average herd size and milk yield (all relative to the comparable conventional farms) are given in Table 1. In Italy and Denmark, two of the five management systems were organic. In Sweden, one out of the four management systems was organic. In the UK, two management systems were organic and one was low-input, out of the five studied.

Farm management information was collected by questionnaire five times over a one-year period coinciding with milk sampling to interpret differences in milk composition [22–24, and Butler et al., this issue]. Udder health related parameters recorded included:

- SCC of the bulk tank milk reported to the farms for the most recent test prior to sampling.
- Number of cows in the herd receiving veterinary treatment in the preceding 3 months for mastitis and other health conditions.

In order to eliminate the substantial inter-country variation observed, all results were expressed relative to a national 'standard', which was calculated as the mean value for all 'conventional' farms in the study from each country.

### 2.2. Study 2. Effects of farm and animal-specific measures

This study consisted of two components. The aim of the first component was to examine the impact of 29 different management factors related to milking measures, hygiene and management on udder health, by assessing the effect of a one-year extension effort on 77 Swiss organic dairy farms [14]. The mean Linear Somatic Cell Score (SCS) per individual cow in the year prior to the investigation was chosen to characterize udder health. The SCS was calculated based on the following equation [25][2]:

$$SCS = \log 2\left(\frac{SCC}{100,000}\right) + 3$$

The aim of the second component was to examine the effectiveness of antibiotics-free dry cow therapy measures by comparing them with an untreated control group. A total of 102 dairy cows

[1] Further details are available from the authors upon request.

[2] This transformation leads to values that are simply related to actual SCC values: SCS 3.0 equates to a SCC of 100 k cells $ml^{-1}$, SCS 4.0 to 200 k cells $ml^{-1}$, SCS 5.0 to 400 k cells $ml^{-1}$, etc. and fits SCC data to a normal distribution.

**Table 1**
Herd size, milk yield and mean somatic cell count (SCC) of milk from organic and low-input systems. All values are relative to a standard taken as the mean value of conventional systems in the same study and country.

| Country | Organic system[a] | n | Herd size | | Milk yield | | SCC | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean (%) | Statistical significance[b] | Mean (%) | Statistical significance[b] | Mean (%) | Statistical significance[b] |
| Italy | North | 25 | 141 | ns | 78 | ns | +14 | ns |
| | Central | 24[b] | 19 | ns | 83 | ns | +27 | ns |
| Sweden | North | 25 | 70 | ns | 58 | ns | +18 | ns |
| Denmark | Maize Silage | 25 | 86 | ns | 87 | *** | +30 | ns |
| | Standard | 25 | 95 | ns | 81 | *** | +4 | ns |
| UK | Northeast | 24[c] | 39 | * | 76 | *** | +28 | ns |
| | Wales | 20 | 90 | ns | 65 | *** | +29 | ns |
| | Low input | 20 | 126 | ns | 67 | *** | +10 | ns |

[a] Different organic systems within a country are distinguished on the basis of region and/or management.
[b] As compared with conventional farms included in the study for each country; ns: not statistically significant.
[c] One sample and record missing.
* $p < 0.05$.
*** $p < 0.001$

were included in the study. Prior to treatment, milk bacteriology and SCC were performed on individual cows. Cows were randomly assigned to the treatments. The cows in the group 'homeopathic dry-cow therapy' (HDT; 32 cows) received a biphasic (before and after dry-off) homeopathic per-oral therapy. Those in the group 'teat sealant' (TS; 36 cows) were treated with a commercial so-called internal teat sealant after the last milking before dry-off, and the ones in the control group (U; 34 cows) were dried off without any treatment. The infection rate (overall, cow associated and environment-associated pathogens) and SCC after calving were compared. Protection odds (odds ratio) after treatment were calculated.

### 2.3. Study 3. The effect of calf-rearing system on heifer performance and udder health

The aim of this study was to examine the effect of calf-rearing method on heifer development and performance, including udder health, using on-farm pilot trials. The focus was to establish whether an integrated management approach, introducing the use of suckling systems in calf rearing, resulted in milking cows with higher levels of udder health and similar milk production compared with cows reared in a bucket-fed system [26]. The following calf rearing methods were compared:

- Bucket feeding with milk replacer;
- Bucket feeding with bulk tank milk;
- Suckling of mother or nurse cow.

The trial was conducted on three farms in the Netherlands. Each rearing group involved 5–8 calves, on average 20 calves per farm. All farms followed identical calf rearing and data collection protocols. Suckled calves stayed with their mother in the milking herd or in a pen with 3 nurse cows (up to 8 calves per cow) for 90 days. Calves from the other two treatment groups were individually housed between birth and 90 days of age. Key parameters assessed were age at first calving, bodyweight at first calving, body condition score at calving, and milk production and milk quality parameters (SCC and bacteriology) during first lactation. Milk production was assessed using the regular milk production recording (MPR) system at 3–4 week intervals. SCC values of heifers were recorded as part of the regular MPR. In addition, quarter milk samples of individual heifers were collected in week 1 and 150 days after calving for determination of pathogens and SCC. Statistical analysis was performed using the General Linear Models procedure of GenStat Eleventh Edition, VSN International Ltd.

### 2.4. Study 4. Evaluation of on-farm measures and a one-year extension programme

The aim of this study was to evaluate and compare the effect of management measures to improve udder health under contrasting environmental conditions in (1) north-western maritime (the Netherlands), (2) southern sub-alpine (Italy), and (3) central sub-alpine and alpine zones (Switzerland). Although criteria to include farms in the study differed among regions, the study aimed to identify general environmental and management factors that need to be considered/included in udder health improvement programmes. A total number of 9 organic Dutch farms (NLORG), 6 Italian so-called 'High-Quality Milk' farms with a past record of low somatic cell counts (ITHQ), 4 Italian organic farms (ITORG), 12 Swiss organic farms practising alpine summer pasturing (CHALP), and 25 Swiss organic farms that graze animals on valley/lowland swards (CHVAL) were included in the study.

Herd management measures applied in a one-year extension period were evaluated. Baseline udder health, average lactation number and milk yield were assessed and compared with the situation one year later. An on-farm questionnaire consisting of 207 dairy management parameters was used as the basis for a 'weak-point analysis'. Monthly milk records available from at least 4 months before until one year after the start of the programme were also processed and analysed. Results from the 'weak-point analysis' were subsequently used to provide advice to the farmers on how to improve udder health, longevity, milk yield and antibiotic use for mastitis treatment and dry cow therapy.

## 3. Results

### 3.1. Study 1. Antibiotic use in low-input and high-input conventional milking herds

The main objective of this study was to compare indicators for udder health (SCC and antibiotic use) in herds under organic, low-input or conventional management conditions.

Mean SCC tended to be higher (up to 30%) in milk from organic compared with conventional production systems. These differences were not statistically significant for any of the countries included in the study (Table 1). However, SCC differed significantly among countries (individual results not shown). In all countries, cows under organic or low-input management received significantly fewer treatments against mastitis than cows in conventional herds, with rates ranging from 23% (in Italy) to 70% (in Denmark) of the national standards (Fig. 1). This may have been because of lower levels of mastitis, a wider use of individual animal specific antibi-

**Table 2**
Overview of the results of applying two antibiotics-free dry-cow therapy measures.

| | | Treatment[a] | | | |
|---|---|---|---|---|---|
| | | HDT | TS | U | Overall |
| No. of cows | | 32 | 36 | 34 | 102 |
| No. of quarters | | 128 | 144 | 136 | 408 |
| No. of clinical mastitis cases | During first 100 days after calving | 3 | 4 | 1 | 8 |
| Negative quarters (%) | Before dry off | 76 | 83 | 79 | 79 |
| | After calving | 81 | 82 | 81 | 81 |
| | After calving, formerly negative | 83 | 82 | 86 | 83 |
| Post-partal normal milk secretion, based on | All observed quarters | 68 | 70 | 65 | 68 |
| SCC and bacteriology (%) | Cows with SCC $\leq$ 200k cells $ml^{-1}$, prior to drying off | 81a[b] | 73ab | 64b | 72 |

[a] HDT: homeopathic dry-cow therapy; TS: teat sealant; U: untreated (control).
[b] Means in the same row, followed by a different letter differ statistically ($p < 0.05$).

**Table 3**
Percentage of Holstein–Friesian blood and performance of experimental heifers reared in different treatment groups; mean and standard deviation (in parentheses).

| | | Suckling $n = 15$ | Bucket-fed fresh cow milk (tank) $n = 11$ | Bucket-fed milk replacer $n = 12$ | Statistical significance[a] |
|---|---|---|---|---|---|
| Holstein–Friesian blood | % | 75 (35) | 77 (25) | 80 (27) | ns |
| Age at first calving | months | 27.2 (2.6) | 25.5 (1.0) | 27.0 (2.7) | ns |
| Live weight at first calving | kg | 543 (66) | 534 (48) | 528 (53) | ns |
| Body condition score at calving | 1–5 | 3.2 (0.45) | 3.4 (0.32) | 3.0 (0.45) | ns |
| First lactation milk production 305 days FPCM | kg | 5690 (899) | 6003 (787) | 5940 (1077) | ns |
| Length of first lactation | days | 339 (70) | 389 (67) | 371 (129) | ns |

[a] ns means in the same row are not statistically different ($p > 0.05$).

otic use and/or a higher threshold/greater reluctance of organic and low-input farmers to use antibiotic treatments for mastitis. This should be investigated in future studies.

### 3.2. Study 2. Effects of farm and animal-specific measures

The aim of this study was to (1) identify management parameters associated with mastitis incidence, (2) design and subsequently evaluate on-farm alternative mastitis management plans, and (3) evaluate the effect of two alternative (antibiotic-free) udder health treatment systems.

Out of the 29 management factors studied, five parameters were identified that significantly affected udder health: (1) breed, (2) alpine summer pasturing, (3) calf feeding with mastitis milk, (4) hard bedding, and (5) post milking abandonment. However, in a one-year extension programme focused on identified management factors, udder health was only marginally improved. The introduction of homeopathy-based alternative udder health management treatments was found not to have had an effect on the mean udder health status across all farms included in the study. However, farms with initially poor udder health were able to significantly improve their udder health status when assessed on the basis of SCC [27].

The homeopathy-based, antibiotic-free dry cow treatments did not improve udder health compared with the untreated control group when the proportion of completely healthy udder quarters after calving (assessed by SCC and bacteriology) was compared for all cows included in the experiments (Table 2). However, in cows with a SCC < 200k cells $ml^{-1}$ at drying off, homeopathic treatment had a significant positive effect on udder health compared with the untreated control group (Table 2). However, there was no significant effect of the teat sealant based antibiotic-free dry cow treatment compared with the untreated control (Table 2).

When the proportions of coagulase-negative *Staphylococcus* spp. (CNS) and environment-associated pathogens was compared during the dry period, CNS infection levels decreased after parturition (11.0% vs. 5.4%), indicating curing effects during the dry period. In the HDT group the proportion of *Staphylococcus* spp. infections decreased from 13% to 1.6%, while there was only a slight decrease in the untreated group (11.7% vs. 7.4%) and the teat sealant group (8.3% vs. 6.9%), indicating positive effects of HDT strategies on CNS infections. As expected, infections by environment-associated pathogens increased during the dry period. *Streptococcus uberis* infections increased from 3.4% of samples before drying off to 5.6% after calving. *Enterococci,* which were not encountered at drying-off, were found in 1% of quarter milk samples post partum, all in the untreated group.

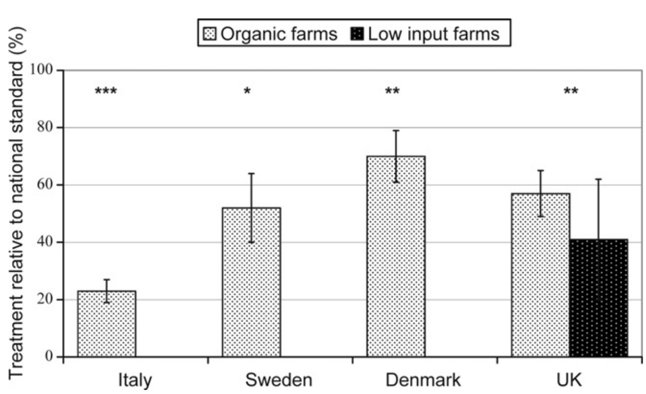


**Fig. 1.** Rates of veterinary treatment on organic and low-input farms, relative to national standard of comparable farms under conventional management (=100%); See text for details of the standards in each country; Error bars indicate standard errors of the means for each group of farms. Statistical significance: $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$.

### 3.3. Study 3. The effect of calf-rearing system on heifer performance and udder health

The objective of this study was to evaluate the effect of different calf-rearing systems on calf development and performance and udder health during later development stages.

Heifers raised in a suckling system did not show significantly improved performance in terms of all growth and udder health parameters assessed, when compared with the bucket-fed groups (Table 3).

**Table 4**
The level of use of alternative health therapies/approaches by areas and farm groups.

| Country and farm group | Number (%) of farms applying other therapies | | | | |
|---|---|---|---|---|---|
| | Nursing calves | Teat sealing | Homeopathy | Milking out | Other complementary |
| Switzerland[a] | – | – | 13 (35%) | 37 (100%) | – |
| CHALP | – | – | 5 (42%) | 12 (100%) | – |
| CHVAL | – | – | 8 (24%) | 25 (100%) | – |
| Italy | – | | 1 (10%) | 9 (100%) | – |
| ITHQ | – | Strategic 3 (50%) | – | 6 (100%) | – |
| ITORG | – | Selective 1 (25%) | 1 (25%) | 3 (100%) | – |
| The Netherlands NLORG | 4 (44%) | Strategic 1 (11%) | 3 (33%) | 4 (44%) | 8 (89%) |

[a] CHALP: alpine summer pasturing; CHVAL: valley/lowlands grazing; ITHQ: high milk quality; ITORG: organic; NLORG: organic.

When bacteriological parameters were assessed in regular MPR milk samples of experimental heifers, mastitis pathogens were in most cases detected in milk samples with SCC > 150k cells $ml^{-1}$. In 25% (72/288) of all negative samples the SCC was higher than 150k cells $ml^{-1}$, in 7% (20/288) higher than 500k cells $ml^{-1}$.

In quarter milk samples from experimental heifers additionally taken at specific times after calving, 94% (137/146) of the quarters were negative for the presence of mastitis pathogens at two weeks after calving. Positive samples included five positive for *Staphylococcus aureus*, two for *Streptococcus dysgalactiae*, and two for minor pathogens. Half of the positive samples were in the suckling group. At 150 days after calving, 96% (114/119) of the samples were negative. Positive samples contained *Staphylococcus aureus* (3), *Streptococcus dysgalactiae* (1), and minor pathogens (1). Again, half of the positive samples were found in the suckling group. At 300 days, 91% (39/43) of the samples were negative. Positive samples contained *Staphylococcus aureus* (1), *Streptococcus uberis* (1), and minor pathogens (2). While the percentage of positive samples was generally considered to be low, milk samples from the suckling group had a relatively high share of positive samples. This should be investigated in future studies.

### 3.4. *Study 4. Evaluation of on-farm measures and a one-year extension programme*

The aim of this study was to compare current practices used for managing udder health and the effect of a one-year extension/advisory programme on udder health management practices in Switzerland, Italy and the Netherlands.

At the start of the programme, the mean Linear Somatic Cell Score (SCS) was 2.77, 3.41, 3.18, 3.50 and 3.21 for CHVAL, CHALP, ITHQ, ITORG, and NLORG, respectively, indicating moderate udder health. However, there were significant differences in the level of use of alternative udder health therapies/approaches (Table 4). Most importantly, in Italy the focus was on hygiene and all farms used teat sealing. On the Dutch organic farms the focus was on labour efficiency rather than on hygiene and a variety of antibiotic-free measures was used to prevent or treat mastitis. In contrast, on the Swiss farms, homeopathy was used more widely, an approach less frequently used on the Dutch farms, and by none of the farms in Italy that were included in the survey.

During/following the one-year extension/advisory period, changes in management practices were observed in all 3 countries. Such changes appeared to depend on (1) the initial (prior to extension period) level of antibiotic use, and (2) the alternative udder health treatment and management strategies used within the respective regions.

All Dutch farms included in the study already focused on minimization of antibiotic use and 6 out of 9 farms did not use antibiotic treatments at the start of the programme. During the extension period only one of the farms treated selected cows with antibiotics and of the 3 farms that used antibiotics at the start of the programme, 2 switched to more moderate use of antibiotics and one stopped using antibiotics.

On the Swiss farms there was no uniform approach to antibiotics reduction prior to the extension/advisory programme, with only 14% (5/37) of farms not using antibiotic therapy. Udder health problems caused by specific micro-organisms on farms with no defined aim to reduce antibiotic use increased antibiotics treatments by approximately 35%. In contrast, farms that already had a defined aim to reduce antibiotic use decreased the amount of chemical treatments by 24%.

All Italian farms used antibiotic therapy prior to the extension/advisory period due to the strong emphasis placed on milk quality and hygiene, and reduction of antibiotic therapy was not a primary goal. During the extension period only 20% of farms decreased, whereas 30% increased the amount of antibiotics used as part of their udder health management programmes and only 10% did not use antibiotics in mastitis treatment at all.

Similar results were found in antibiotic Dry Cow Therapy (DCT). Prior to the extension programme seven out of nine Dutch farms used DCT on selected cows. After the one-year extension period only two farms were pursuing this strategy. On the Swiss farms the number of farms not using DCT decreased from 22 to 14. However, of the 13 farms that used DCT on selected cows at the start of the programme, four stopped using DCT altogether. On the Italian farms the goal was not to reduce DCT systematically, but three out of the seven farms treating all cows by DCT prior to the extension programme switched to using DCT on selected cows only.

Improvement of udder health status during the one-year programme depended strongly on the mean herd SCS before the programme started. Udder health status of farms with a mean SCS below 3.0 (=100k cells $ml^{-1}$) could not be improved whereas farms with higher initial SCS showed a significant decrease of SCS by 0.2. Milk yield and mean lactation number did not change significantly.

## 4. Discussion and conclusions

The above results suggest that udder health can be maintained in a variety of organic and low-input dairy production systems. For example, the results from Study 1 confirm that cows managed under organic or low-input systems were not compromised with respect to udder health, as indicated by the relatively low SCC of bulk tank milk. This was despite antibiotic use being significantly lower in organically managed herds. These results suggest that the preventative management practices used in organic farming systems provide efficient protection against udder disease.

None of the studies identified new factors/variables affecting udder health. Study 2 identified five factors significantly affecting udder health (e.g., post milking measures and feeding management of calves).

However, the effects of individual or integrated alternative approaches to maintain udder health, and their introduction into commercial practice via extension programmes, requires further investigation, as a range of QLIF studies remained inconclusive. Most importantly, many of the alternative measures tested to prevent or control mastitis were shown to be not (e.g., teat sealants) or only partial effective. Teat sealants in Study 2, and the use of suckling systems (although having a positive effect on the growth of calves [26]) in Study 3 had no significant effect on udder health. On the other hand, some strategies could be linked to significant positive effects. Most importantly, in Study 2 the homeopathic dry-cow therapy (HDT) approach reduced SCC compared with the untreated control in cows with relatively low SCC status.

Although the results of different alternative approaches to improve udder health were presented in this paper, there is still a gap with respect to preventive measures that allow reductions in infections during periods of high risk especially after 'drying-off' and in the first month post partum.

The use of extension/advisory programmes developed by Forschungsinstitut für Biologische Landbau (FiBL) and Louis Bolk Institute (LBI) was successful in improving udder health in herds with initially low udder health, but not in herds where established practices had already resulted in effective mastitis control. This strongly suggests that individual extension approaches over a longer period, rather than standardized weak-point enhancement, could be a solution for better udder health performance in organic and low-input dairy herds, and improve on the results presented in Study 4. For example, the consideration of farmer-related strategies, e.g., consequent avoidance of chemical drugs versus targeted SCC improvement, should be in the focus of future extension concepts. There is also a need to address the diversity of individual farmers' problems and coping strategies, when targeting udder health improvement with an extension approach.

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